

PHOBOS Status and Perspectives

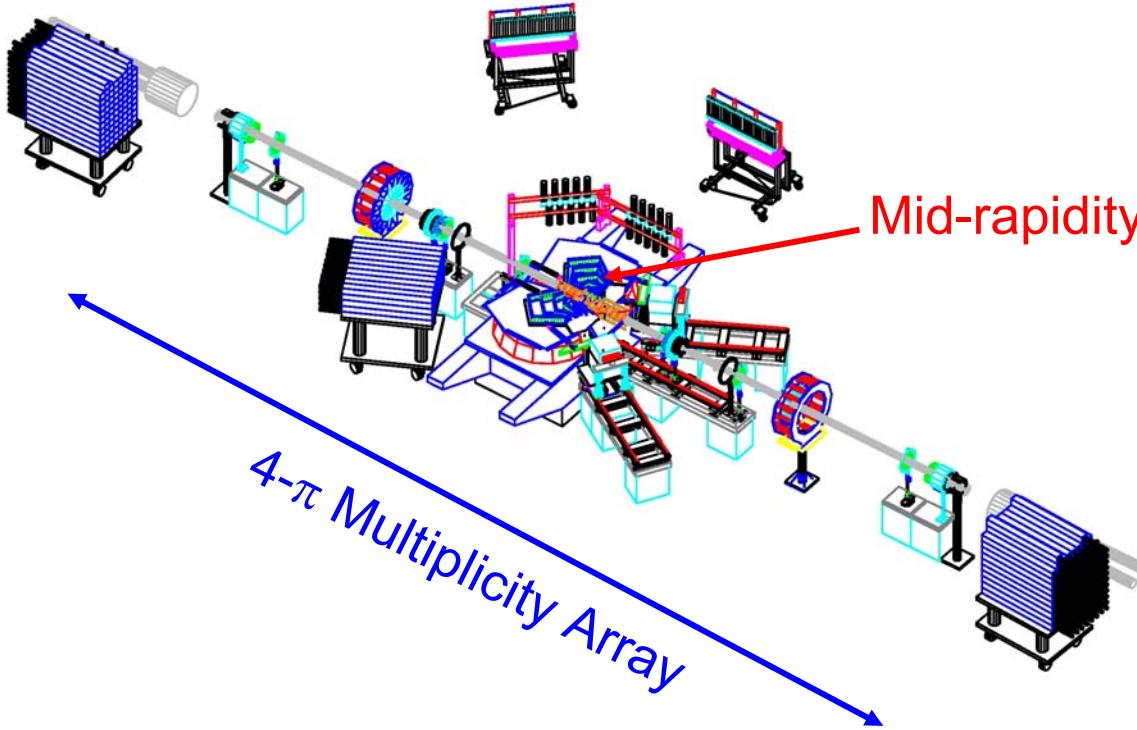
The PHOBOS Collaboration:

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UNIVERSITY OF ILLINOIS AT CHICAGO
UNIVERSITY OF ROCHESTER

PHOBOS Experiment - Run 5



Mid-rapidity spectrometer

4- π Multiplicity Array

First collisions June 13, 2000

Run 1: First spectrometer arm
Run 2: Second spectrometer arm
Run 3: Spectrometer trigger, PCAL-N
Run 4: MCAL, PCAL-P

+ continuous DAQ upgrades (x25)

PHOBOS Experiment - now

30 Publications (as of July 2006)

- 13 PRL, 14 PRC (RC), 1 PLB, Whitepaper

12 PhDs awarded (as of July 2006)

- 11 still in physics
- 7 in heavy-ions, 2 in HEP, 1 LIGO,
1 neutrinos

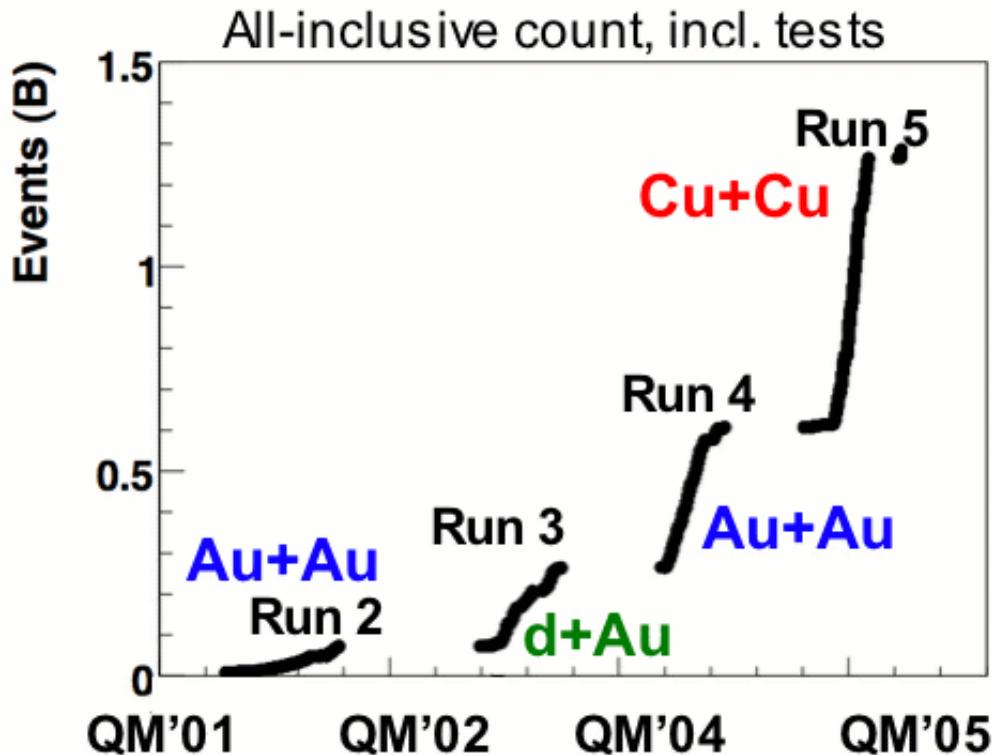
12 current PhD students

- expect >50 total publications

Analysis will continue for 1.5 to 2 years

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

PHOBOS Experiment - Data sets



All events reconstructed and available on disk at RCF

Full Cu+Cu dataset used for PRL 96 212306 (2006)

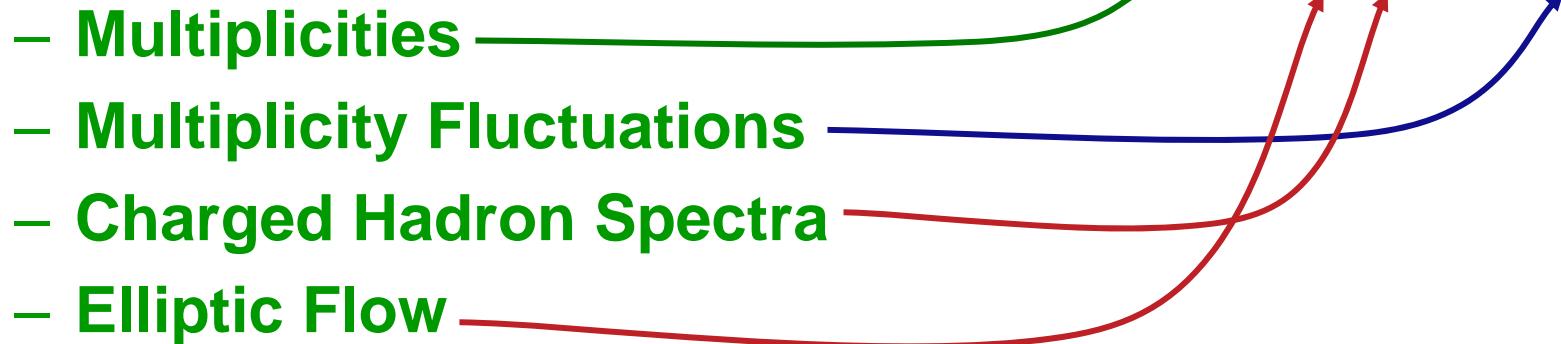
Need continued computing support at RCF

Results and Perspectives

Overview

time →

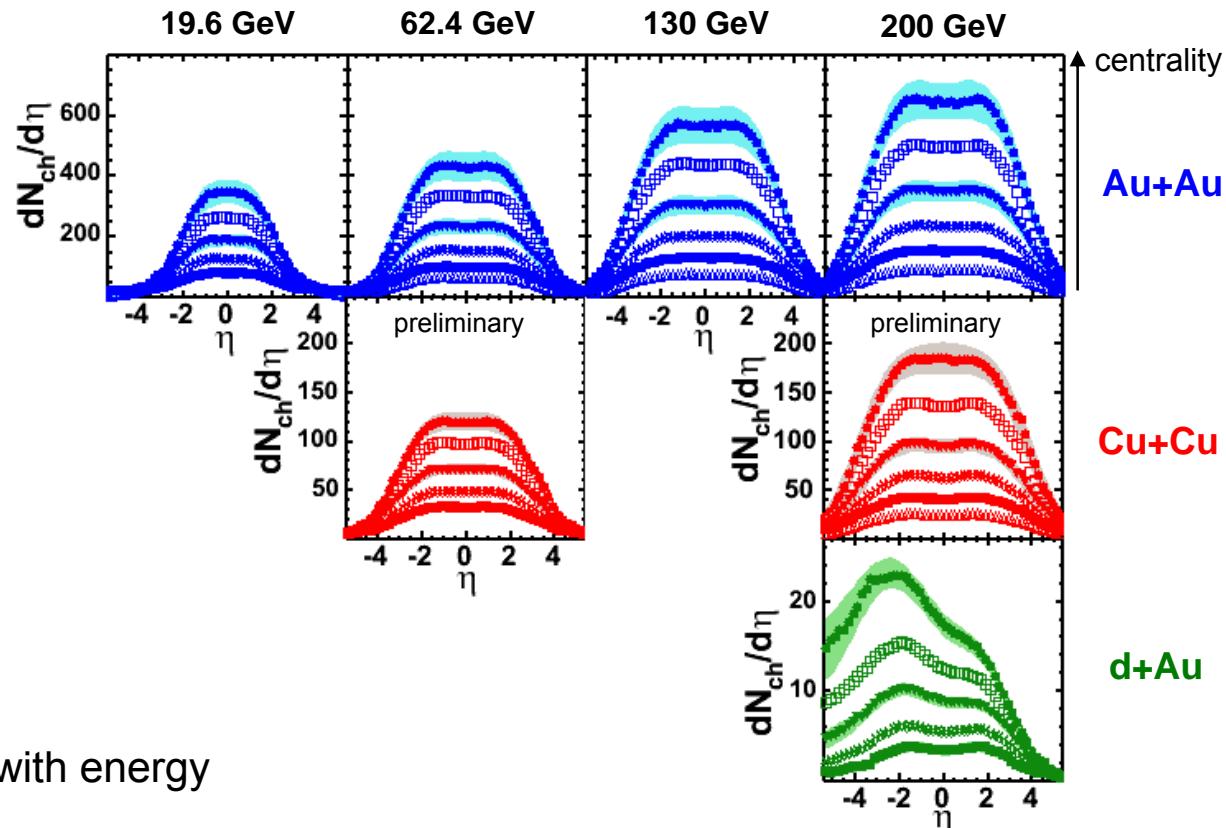
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- **Results: What have we learned?**
- **Perspectives: What is left to do?**

Multiplicity Results

Phys. Rev. Lett. **85**, 3100 (2000)
Phys. Rev. Lett. **87**, 102303 (2001)
Phys. Rev. Lett. **88**, 22302 (2002)
Phys. Rev. C**65**, 31901(R) (2002)
Phys. Rev. C**65**, 061901(R) (2002)
Phys. Rev. Lett. **91**, 052303 (2003)
Phys. Rev. Lett. **93**, 082301 (2004)
Phys. Rev. C**70**, 021902(R) (2004)
Phys. Rev. C**72**, 031901(R) (2005)
nucl-ex/0301017, PRC in press
nucl-ex/0509034, PRC in press



- Slow, logarithmic rise of $dN/d\eta$ with energy
- Limiting fragmentation scaling
 - all systems, energies, centralities
- N_{part} scaling and “universality” of total multiplicity
- Factorization of energy and centrality dependence

Multiplicity Results

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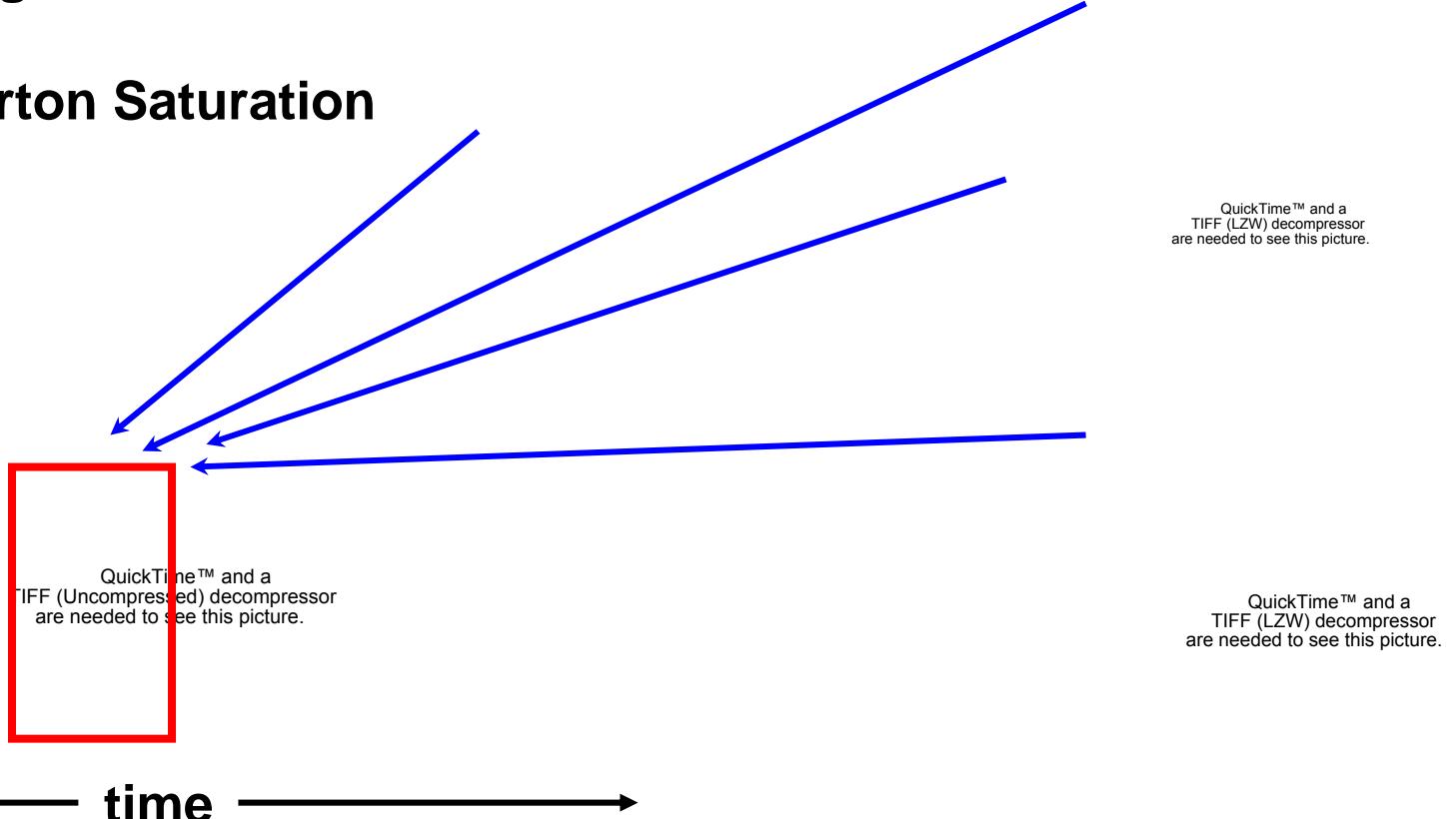
QuickTime™ and a
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Multiplicity Results: Early Stage Entropy?

Scaling laws connect A+A
and elementary systems

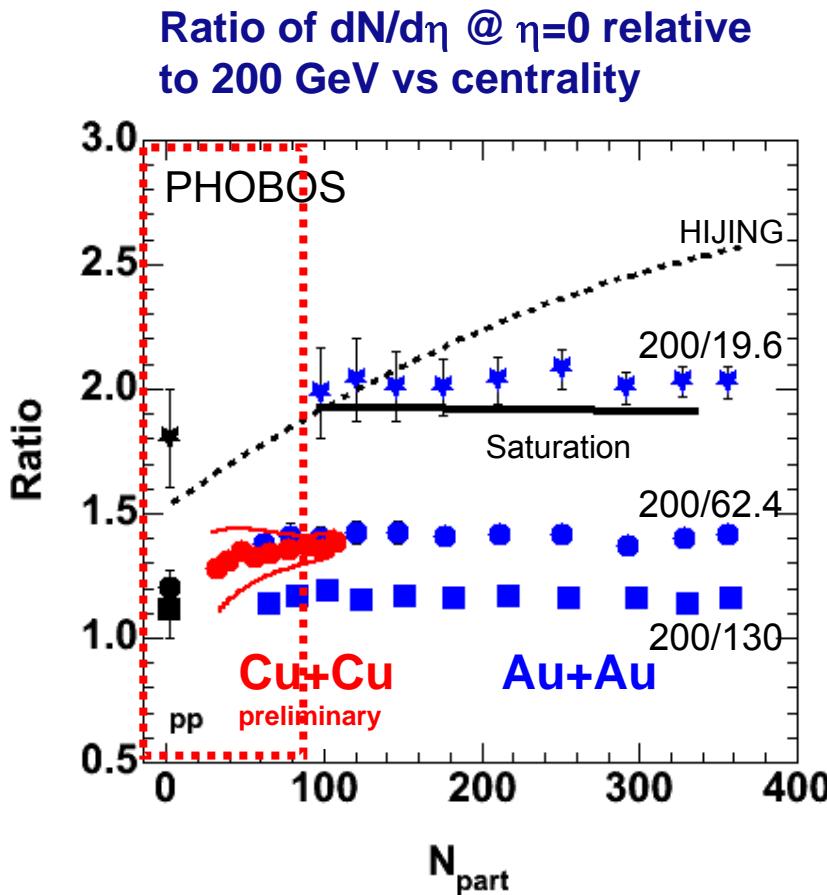
Definition of multiplicity
in initial stage?

c.f. CGC/Parton Saturation

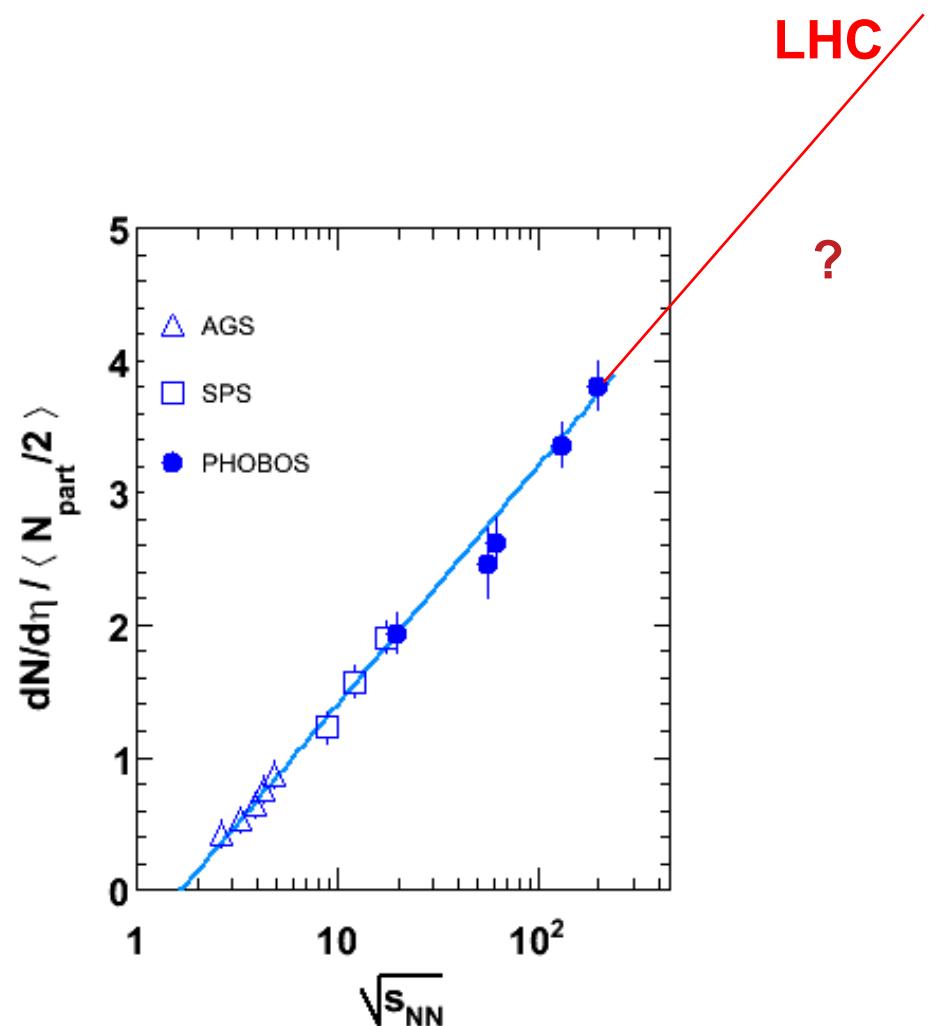


Multiplicity Perspectives: Small systems and large energies

nucl-ex/0509034, PRC in press

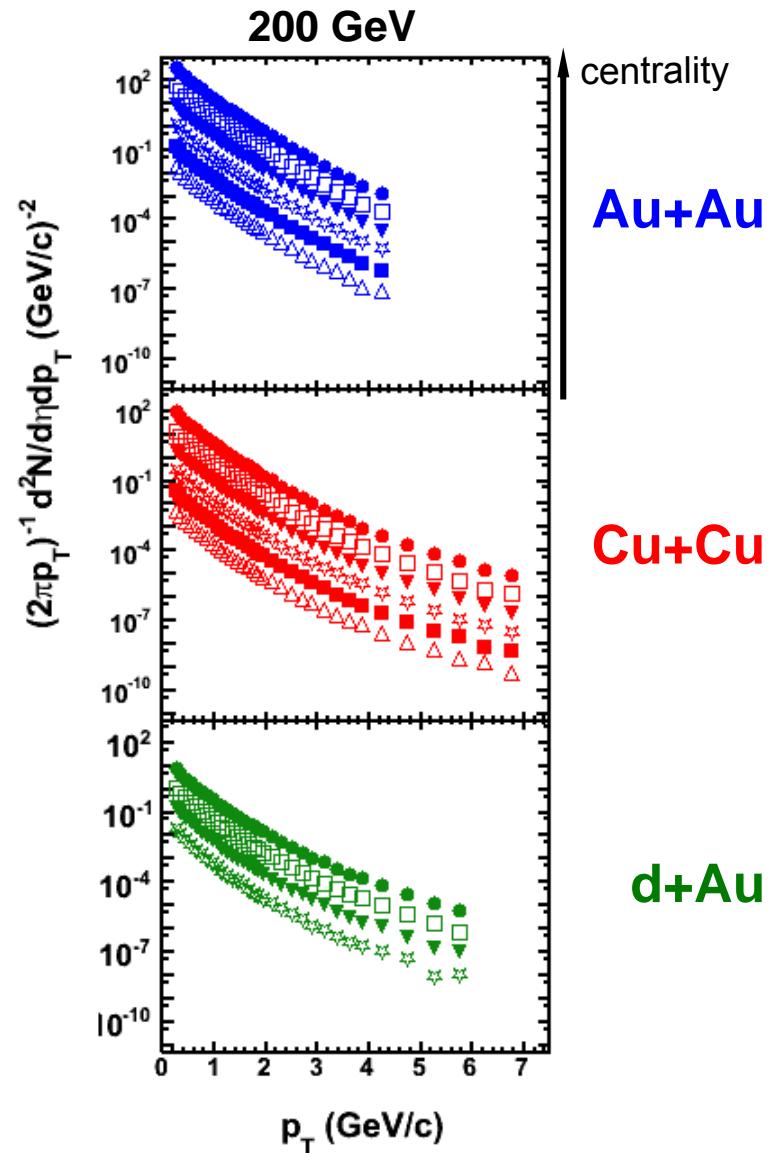
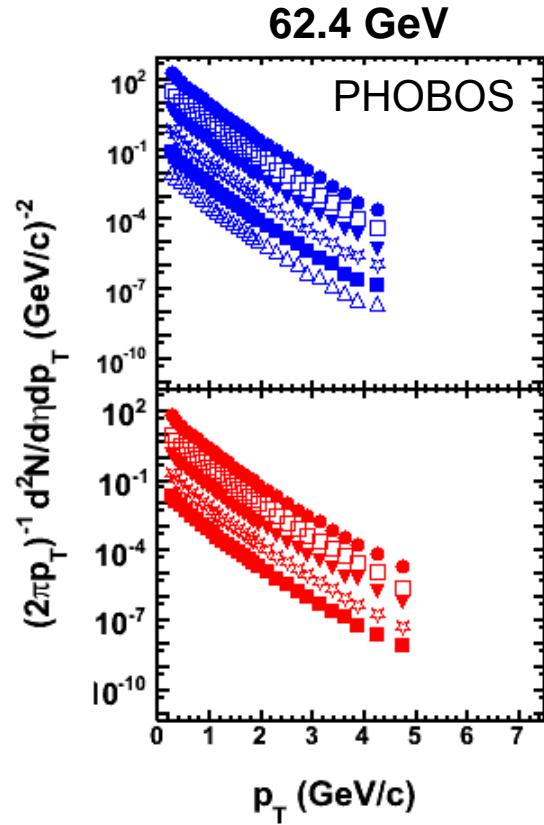


Study scaling for small N_{part} in Cu+Cu and Au+Au



Definitive answer from LHC

Spectra Results



Phys. Rev. Lett. 91, 072302 (2003)

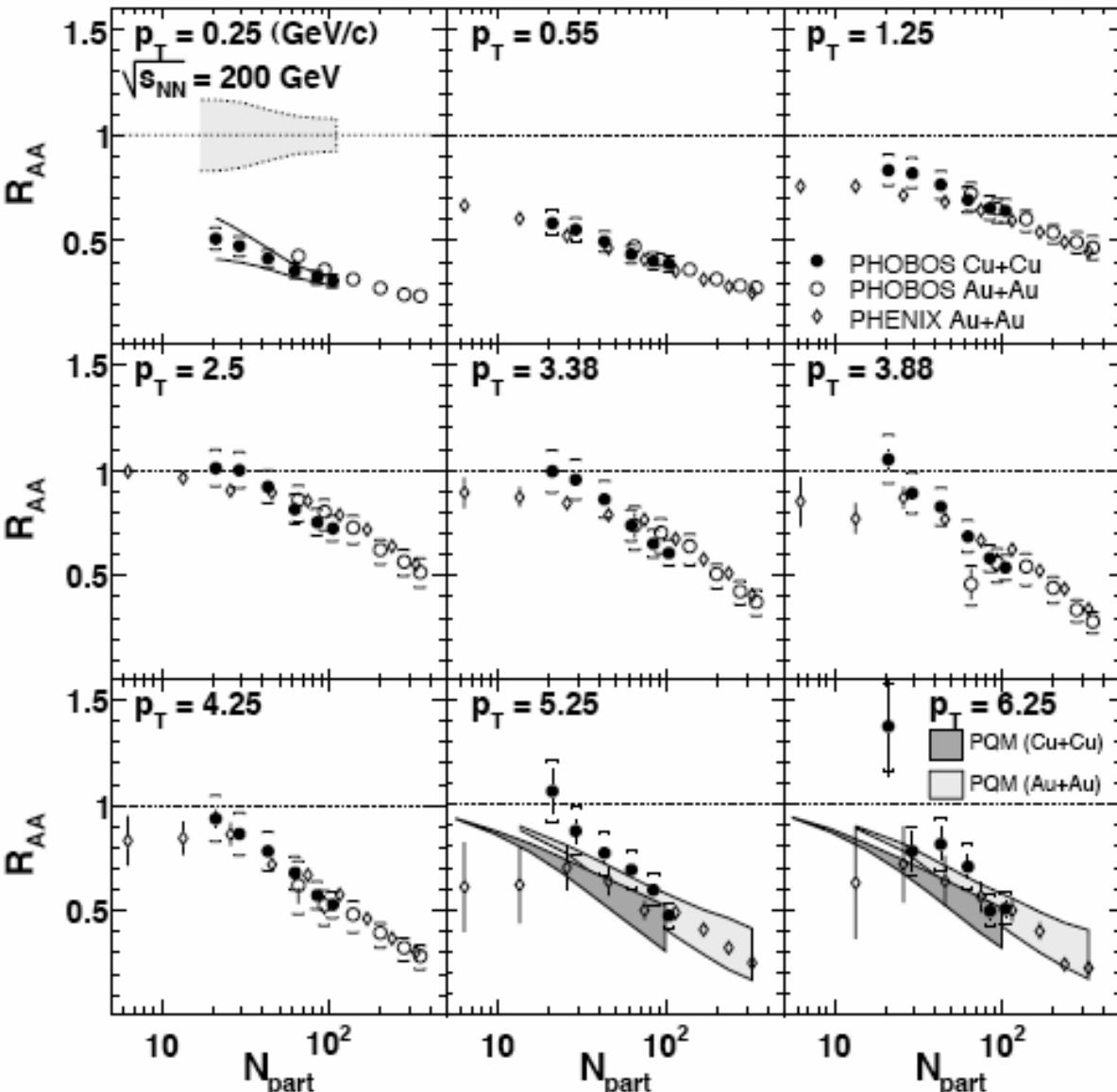
Phys. Lett. B578, 297 (2004)

Phys. Rev. C70, 061901(R) (2004)

Phys. Rev. Lett. 94, 082304 (2005)

Phys. Rev. Lett. 96, 212301 (2006)

Spectra Results: System-size Scaling



PRL 96 212306 (2006)
[first RHIC paper from Cu+Cu run]

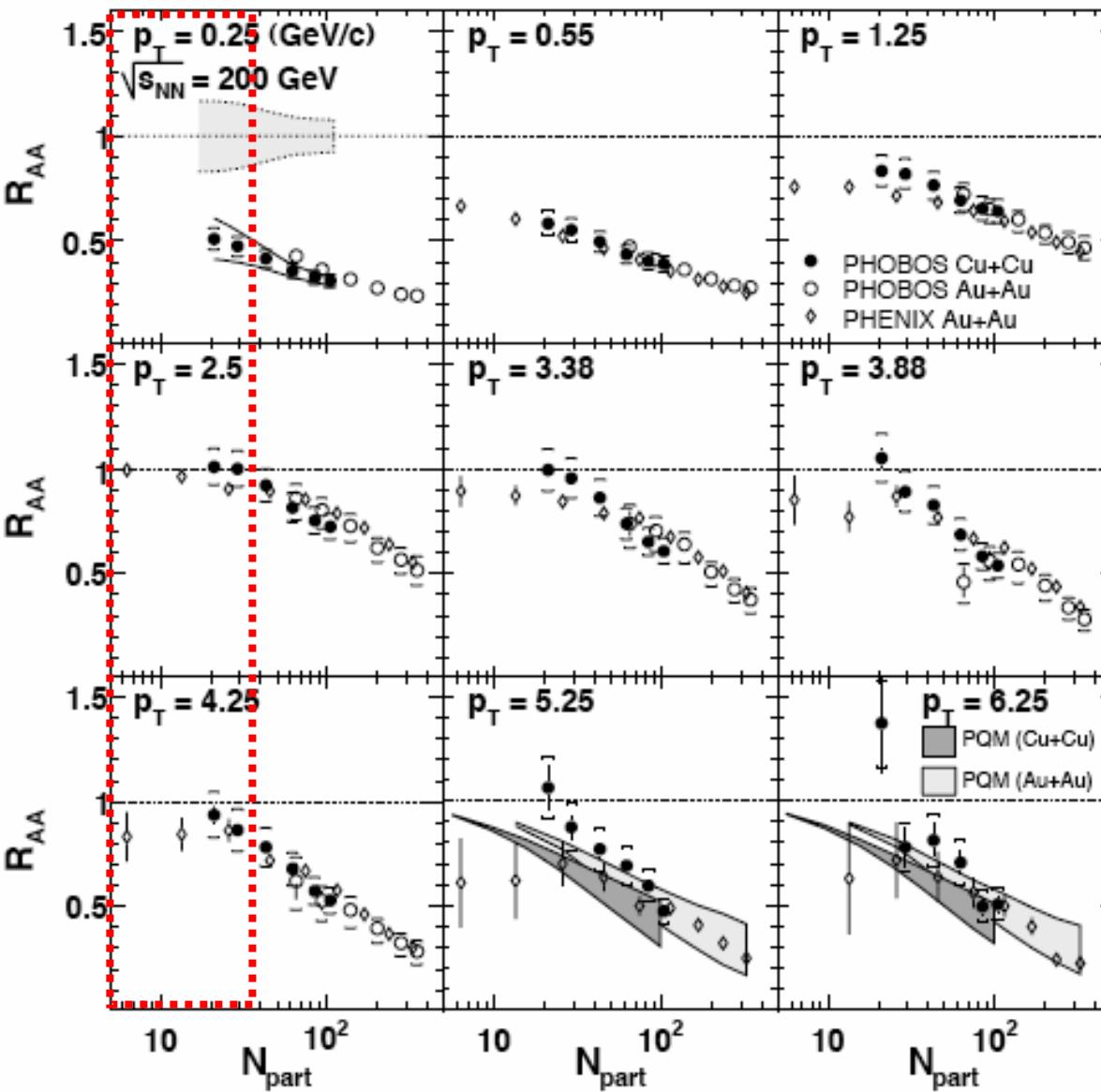
Same R_{AA} in Cu+Cu and Au+Au for same N_{part}

From $p_T = 0.25 \text{ GeV/c}$ to 6.25 GeV/c

time →

QuickTime™ and a TIFF (Uncompressed) decompressor are needed to see this picture.

Spectra Perspectives: Small systems - very peripheral A+A



Extend centrality range
in Cu+Cu and Au+Au

Turn on of N_{part} scaling
and energy/centrality
factorization

Fluctuation Results: Forward/backward correlations

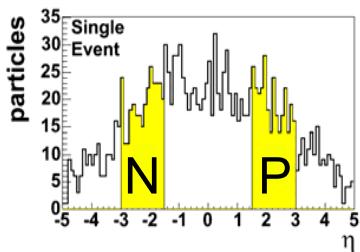
nucl-ex/0603026, PRC RC in press

Clusters →

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Particles produced
in clusters
(~2-3 hadrons/cluster)

Poisson →

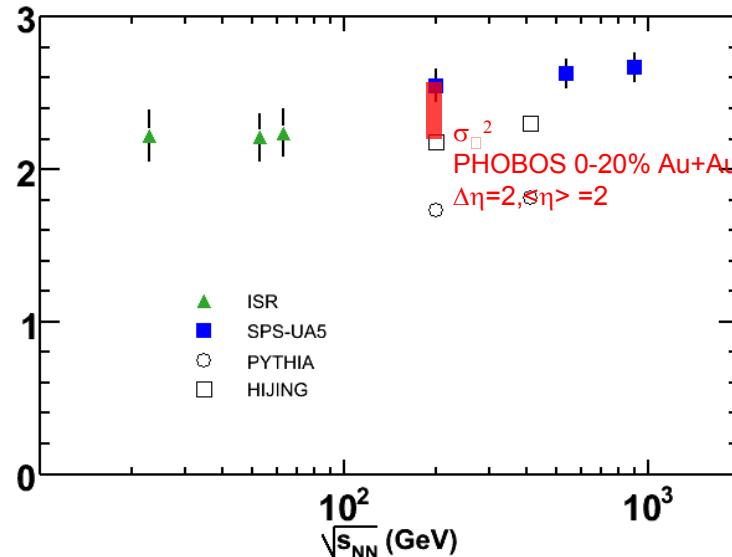


$$C = \frac{P - N}{\sqrt{P + N}}$$

$$\sigma_C^2 \sim \langle K_{\text{eff}} \rangle$$

Cluster size K

K_{eff}



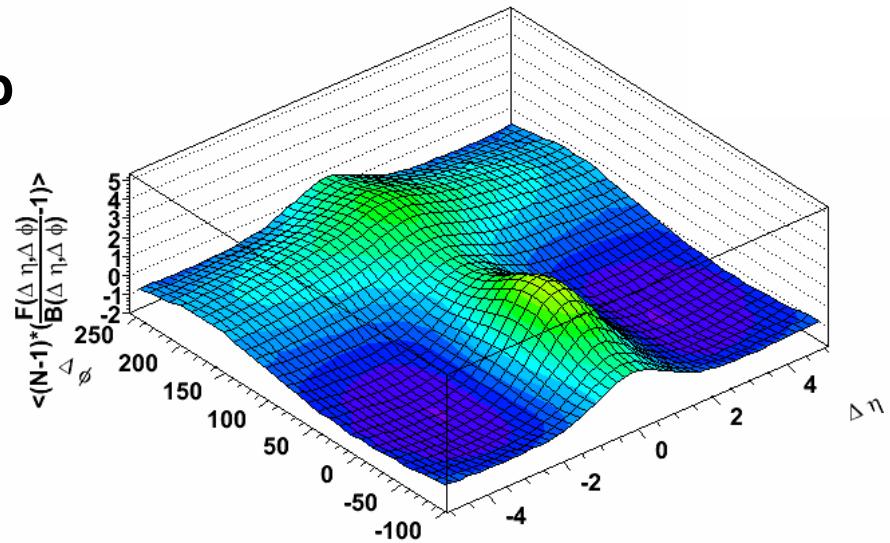
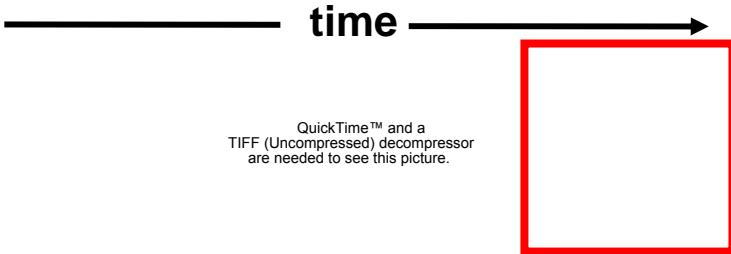
Clusters from
Resonances
(c.f. UA5)

UA5: PLB 123 (1983)

Fluctuations Perspectives: 2-D Angular Correlations

Cluster “size” in Au+Au similar to p+p

An effect of hadronization?

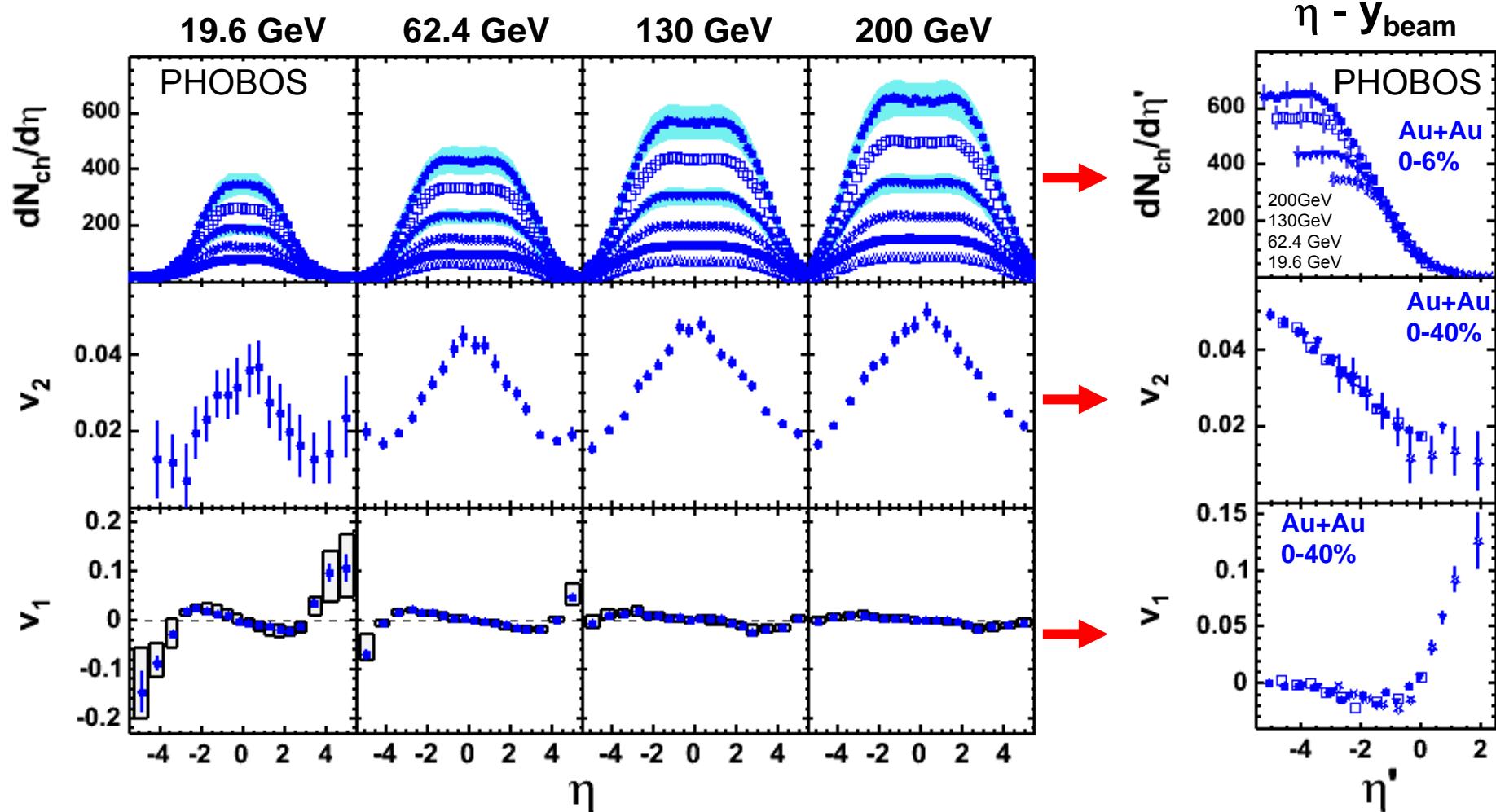


“Clusters” in $\Delta\eta, \Delta\phi$ space via
2-particle correlations
(Pythia p+p @200 GeV, $\eta < 3$)

Comprehensive study of angular correlations
in p+p, d+Au, Cu+Cu, Au+Au vs energy, centrality

Disentangle hadronization, mini-jets, flow

Elliptic and Directed flow in Au+Au



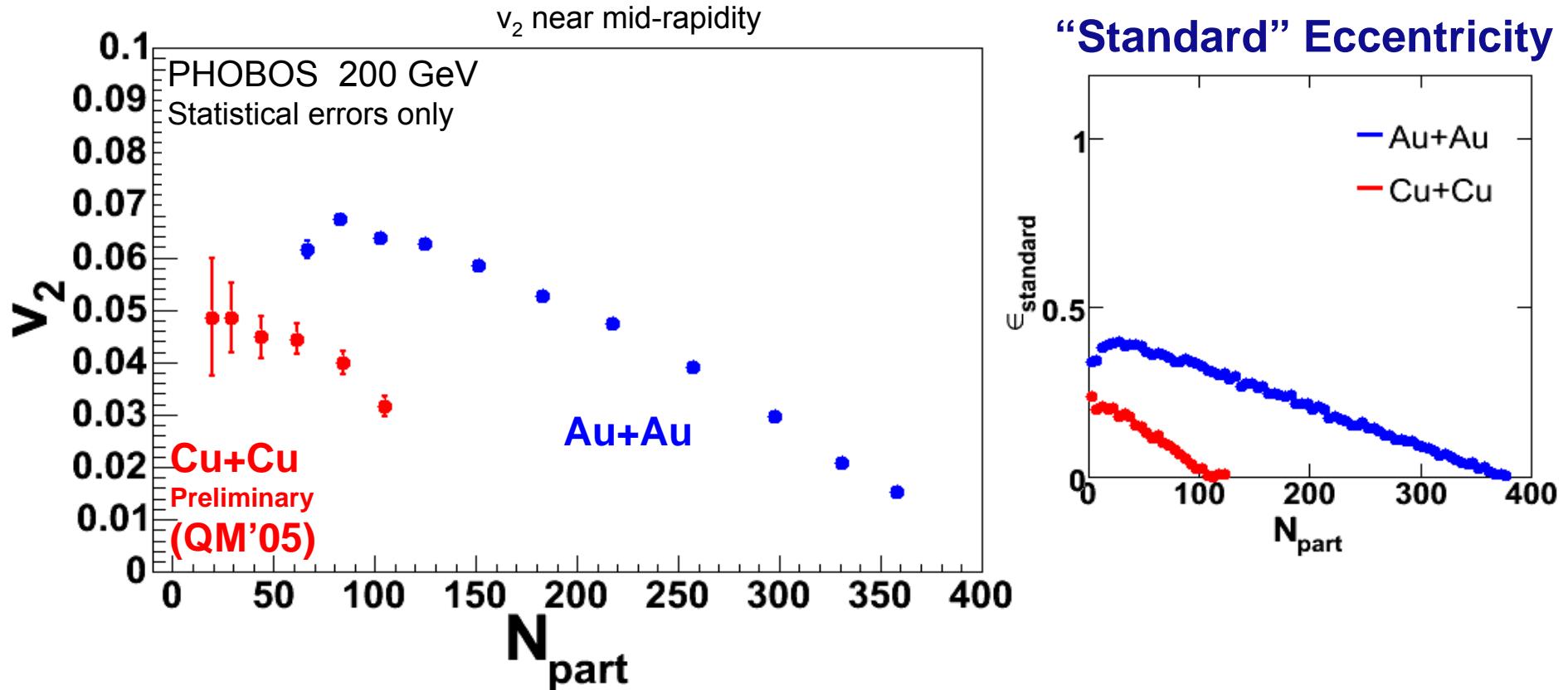
Phys. Rev. Lett. **89**, 222301 (2002)

Phys. Rev. Lett. **94**, 122303 (2005)

Phys. Rev. C**72**, 051901(R) (2005)

[nucl-ex/0511045](#), PRL in press

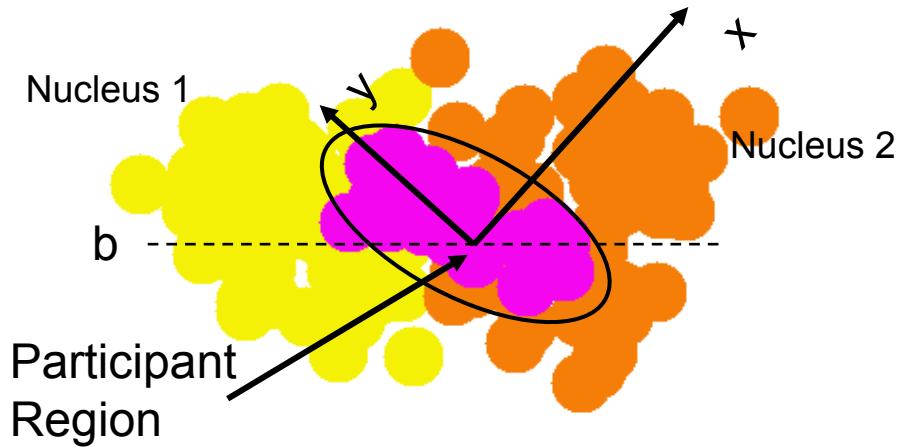
Elliptic Flow Results: Centrality Dependence



Large v_2 signal for Cu+Cu,
even for central events

Elliptic Flow Results: Eccentricity Scaling

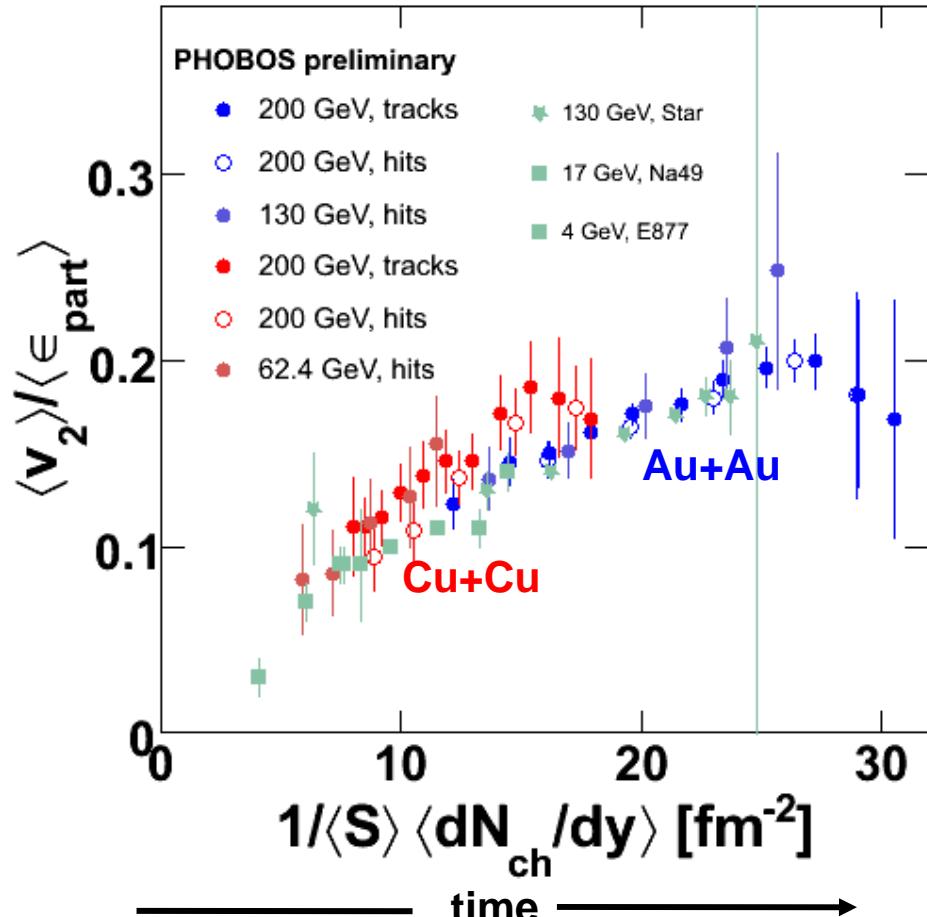
Participant Eccentricity



Event-by-event shape of participant region drives v_2

Unified description of v_2 vs geometry in Cu+Cu and Au+Au

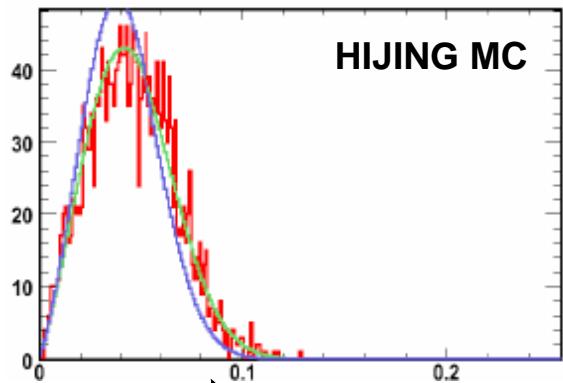
Participant Eccentricity



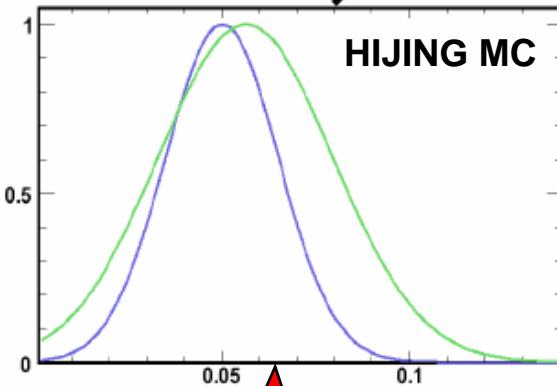
QuickTime™ and a
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Elliptic Flow Perspectives: Event-by-event Fluctuations

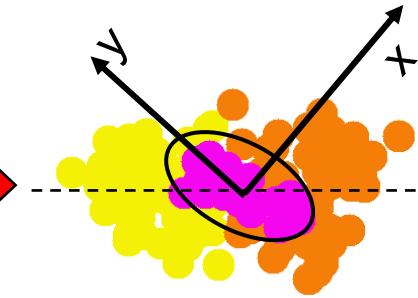
Observed v_2 Fluctuations



True v_2 Fluctuations



ϵ_{Part} Fluctuations

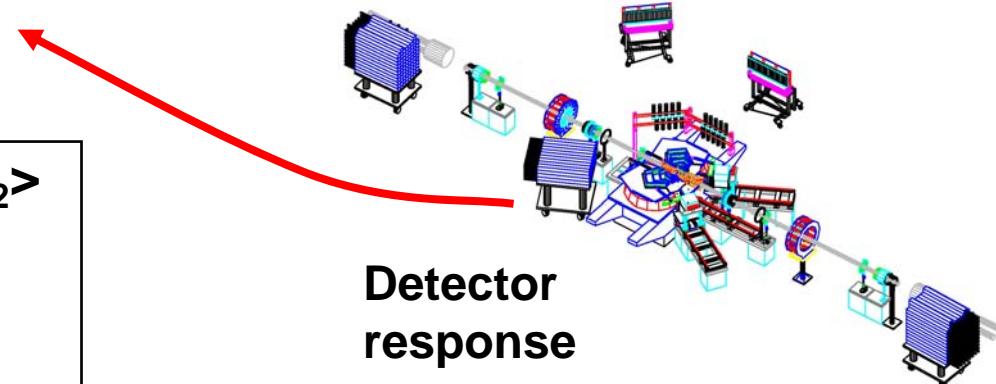


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Study higher moments beyond $\langle v_2 \rangle$

Event-by-event v_2 fluctuations

2-D angular correlations



Detector
response

Summary

Results and Perspectives:

- **Comprehensive multiplicity systematics**
 - Initial stage entropy production
- **Onset of scaling behavior for peripheral events?**
- **Connection of multiplicity fluctuations and hadron clusters**
 - Clusters at hadronization (resonances)
- **Comprehensive study of angular correlations**
- **Elliptic flow in small systems; connection to initial geometry**
 - Coupling of initial geometry and hydro evolution
- **Elliptic flow fluctuations**